INTERNATIONAL JOURNAL OF
PHARMACEUTICAL AND HEALTHCARE INNOVATION
journal homepage: www.ijphi.com

Research Article

OPEN ACCESS

Air Pollution effect on Cardio Fitness and Mental Health of Sport Athletes

Meenakshi Rani*[1], Dr. Deepak Raghav[2], Sneha[3], Vikrant Baliyan[4]
[1,3,4] Research scholar, Department of Physical Education, S. V. S. University, Meerut.
[2]Assistant professor, Department of Physical Education, S. V. S. University, Meerut.

Article Info

Article history:

Manuscript ID:

IJPHI1908250826092026
Received: 19-AUG -2026
Revised : 25-AUG -2026
Accepted: 09-SEP-2026
Available online: SEP 2026
DOI:
doi:10.62752/ ijphi.v3i2.271

Keywords:
Air Pollution, Cardio Fitness, Mental Health, Sport Athletes

Corresponding Author:
meenakshishooter2020@gmail.com

Abstract

Background: *Engaging in outdoor sports in urban and industrialized environments exposes athletes to high concentrations of ambient air pollutants, including fine particulate matter (PM2.5, PM10 nitrogen oxides (NOx), ground-level ozone (O3), and carbon monoxide (CO)). During strenuous exercise, exponential increases in minute ventilation and a shift toward oral breathing bypass the nasal passages' natural filtration system, substantially increasing the inhaled pollutant dose. This study investigated the dual physiological and psychological consequences of acute and chronic pollutant exposure on competitive and recreational athletes.*

Methods: *This paper reviews the current physiological, cardiovascular, and psychological literature concerning athletes exposed to varying air quality indices (AQI). Key physiological parameters—such as maximal oxygen uptake (VO2 max), endothelial function, autonomic balance, and pulmonary flow—alongside indicators of mental health (e.g., perceived exertion, mood states, and systemic neuro-inflammation-linked cognitive fatigue), were synthesized to evaluate overall athletic performance and wellness decrements.*

Results: *Cardiorespiratory Fitness and Physiological Impairment: Inhalation of particulate and gaseous pollutants induces localized airway inflammation, systemic oxidative stress, and endothelial dysfunction. Carbon monoxide competitively binds to hemoglobin to form carboxyhemoglobin, directly decreasing oxygen-carrying capacity. Consequently, athletes exhibit acute reductions in VO2 max, early onset of exhaustion, increased systolic blood pressure, and decreased aerobic endurance metrics, culminating in measurable declines in competitive race performance. Issues of spatial inequity, leakage, and the city as a whole failing to fully consolidate gains.*

Introduction

University students are facing a growing mental health crisis, marked by surging levels of anxiety, depression, and stress. This urgency is intensified by increasing suicide rates among at-risk groups, signalling that traditional therapy alone is no longer sufficient. While exercise is a proven mental health booster, physical education (PE) majors deal with specialized pressures such as the risk of injury, performance demands, and the struggle to balance sports with academics, which can counteract the natural psychological benefits of staying active. Auerbach RP, et. al. (2018). Physical activity subjects the heart to periodic hemodynamic shifts, characterized by pressure and volume overload. To manage these stressors and satisfy the body's heightened need for oxygenated blood, the heart undergoes structural adaptations—specifically, an increase in cardiac mass and ventricular wall thickness. This growth, known as adaptive remodeling, is driven by the enlargement of individual, mature cardiac myocytes. Unlike pathological remodeling caused by chronic conditions like hypertension or aortic stenosis, which often leads to diminished contractile function and eventual heart failure—exercise-induced changes typically maintain or even improve the heart's pumping efficiency. Borlaug BA, Lam CS, et. al. (2009). Air pollution now stands as a premier global threat to both environmental stability and public health. Driven by rapid industrial growth, urban expansion, and seasonal agricultural burning, air quality has plummeted—most notably across North India. The World Health Organization (WHO) has linked fine particulate matter, including $PM_{2.5}$ and PM_{10}, to severe respiratory and heart-related illnesses. However, while the dangers to high-risk groups like children and the elderly are well-established, there is still a significant gap in understanding how these pollutants specifically affect young, healthy athletes. Adams, W. C. et. al. (2006). Student athletes are a physiologically unique demographic whose training habits increase their vulnerability to poor air quality. During intense exercise, athletes experience elevated minute ventilation and often switch to mouth breathing, which bypasses the natural filtration system of the nasal passages. This increased respiratory demand leads to a higher concentration of pollutants being deposited deep within the lungs. Long-term exposure to contaminants—including particulate matter ($PM_{2.5}$ and PM_{10}), NO2, SO2, O3, and CO–can damage lung function, hinder oxygen diffusion, and lower overall cardiopulmonary efficiency. Ultimately, these physiological stressors may diminish maximal oxygen uptake VO2 text max, reduce endurance, and stifle athletic performance. Balakrishnan, K., Dey, et. al. (2009).

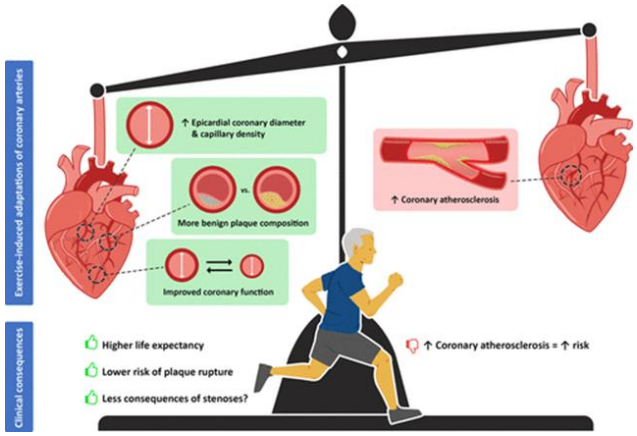


Figure: 1 cardiac health and sports

To identify and monitor the health and cardiovascular fitness for participating in the game event, it is quite accessible to identify healthy players who could participate. Athlete body parts, especially airways, may be affected while they play in polluted air conditions, where there is a high risk of throat and lung inflammation. When small pollutants get inside to lungs tissues it gets deeper and cause severe inflammatory small particles of pollutants are easy to pass the blood vessels therefore get exposed oxidative stress create tissue damage. This imbalance causes irregular stress, protein damage, and lipid peroxidation along with degenerative disorders, while elevating the score of reactive species in the body. For their identification some of identification markers like super oxidase, catalase, and reactive

species. provide measurable indicators of oxidative and inflammatory status. Major problems during training include fatigue due to the elevated levels of reactive species. Lim, Y. H., Kim, H., et. al (2012). This impact of pollutants extends to only the lungs, but it spreads all over the body, which is more prone to disease or inflammatory disorders, such as heart disease, kidney, protein metabolism, etc., due to excessive pollutants such as CO, SO2, NO2, and O3. These gases may intensely lead to anxiety; schizophrenia spectrum ceases along with several other consequences that are severe for athletes. The methodology involved in the pathology.

The process involves the direct import of very fine particles to the brain via the olfactory or systemic nerve inflammatory sites. Hence, it imparts health life stress impaired valuable life particular welfare. These health problems, such as neuro-inflammatory causes, sleep abruption or disturbance, and mood changes, are commonly reported in cases of exposure to polluted environments. Peng, D.; Liu, X.Y., et. al (2025)

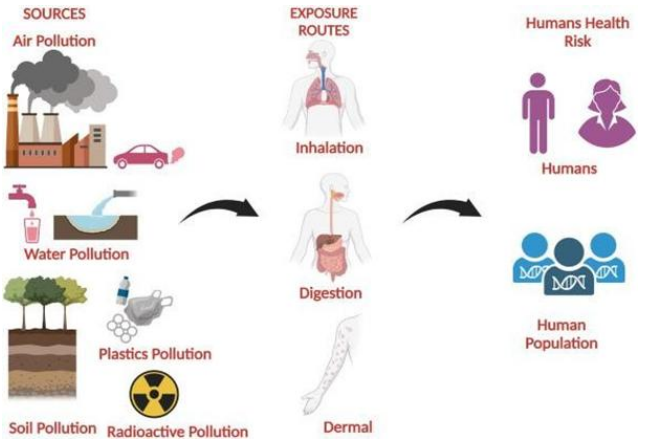


Figure 2: Impact of pollutants on health issues and their major sources

Impact on Mental Health

Long-term exposure to pollutants penetrates the blood vessels and creates a panic situation; pollutants such as PM2.5 nitrogen di oxide and ozone (O3) are harmful and have a negative impact on brain cells and neuronal inflammation inside the brain. Hence, it produces an inflammatory cascade that leads to health impairments in athletes. Over time, it could lead to more stress when it goes unhealthy than another impact of sports performance. All these happen to long exposure for people who lived in cities along with more prone towards high risk of workout in high risk of raising pollutants.

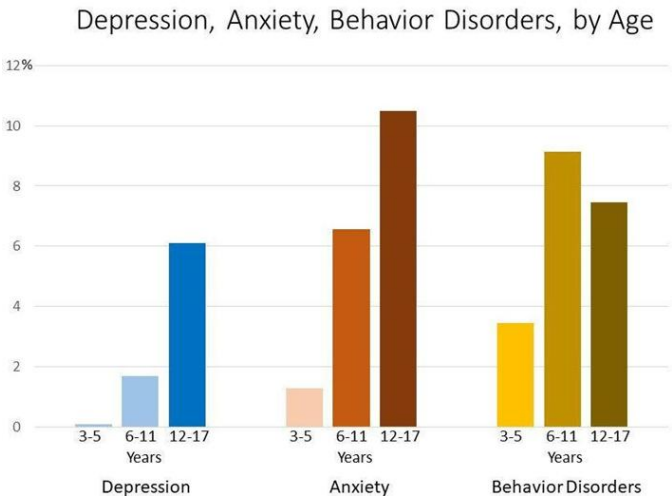


Figure:3 Age-related data on air pollutants and mental health

Evidence from Studies

Most studies align to the mental risk factor during sports activity for athletes a similar investigation remark about the health education university of Washington published in health and place it concluded that high level of PM 2.5 develops more stress along with anxiety. Hence the mental health is affected via several other mental disturbance while it uses more prompt towards health risk statistics.

Vulnerable Populations and Solutions

The attacks of pollutants on the community, which has lower financial conditions, make them more prone to pollutants. Some of them do not have mental or physical health counselling and caring for the next step of health.

Mechanisms of Impact

Scientists are still studying the mental health impacts of air pollution, but they have some ideas. Inflammation and cell damage: At a very small scale, pollutants derogetly enter the lungs via airways like

PM2.5 and these further lead to inflammation. This can lead to abrogation of brain cells and cause neuroinflammation. Hence, it leads to memory loss.

Brain Chemical Imbalance: Air pollution may affect important brain chemicals, such as serotonin and dopamine, which control mood and emotions. This could increase the risk of depression, anxiety, and even serious mental health conditions, such as schizophrenia.

Increased Stress: Prolonged exposure to contaminated air can increase stress levels, raising the stress hormone cortisol. This can eventually lead to melancholy, anxiety, and sleep difficulties.

Statement of problems:

Modern athletic training conditions are becoming more incompatible with human physiological constraints, which is the main issue. Even with improvements in sports science, nutrition, and recuperation, air quality remains an uncontrollable environmental issue. “Negates exercise Gains: The increases in mitochondria that are expected during exercise may be negated by the inflammatory reaction to pollution.

A higher "biological tax" is imposed on athletes in developing urban areas than on those in rural or filtered environments, which leads to health disparities.

Endangers Long-Term Health: Retired athletes who trained in "red zone" air quality for years are experiencing an increase in exercise-induced asthma and cardiovascular issues.

Methodology (Materials & Methods)

Research becomes successful with a systematic and organized process. With the help of a scientific approach, the present study entitled “Air Pollution Effect on Cardio Fitness and Mental Health of Sport Athletes” was carried out following the methodology described below:

Data Source

Sport athletes from M. M. COLLEGE OF PHYSICAL EDUCATION, MODINAGAR, GHAZIAABD

Sports academies and training facilities provided the data for this study. There were two types of data sources: main and secondary. While secondary data were gathered from journals, publications, and published literature, primary data were gathered through questionnaires and field assessments.

Subject Selection

Male and female athletes between the ages of 18 and 25 participated in the study. A total of 30 athletes, including those from team sports and endurance, were selected at random. Based on their exposure to the environment, the participants were divided into two groups:

Group A: Sportsmen in regions with high levels of air pollution. Group B: Sportsmen in regions with no air pollution.

Sampling Procedure

The participants were selected using random sampling techniques. Active athletes with at least two months of training experience met the inclusion criteria. The study did not include athletes with known respiratory conditions, mental issues, or cardiovascular ailments.

Selection of Variables

The following variables were selected for the present study: Independent variable: Air pollution exposure (PM2. $_5$, AQI levels) Dependent Variables: Cardiorespiratory fitness, Mental health status

Selection of Tests and Criterion Measures

Cardiorespiratory fitness was assessed using the Cooper 12-min run/walk test. The distance covered in 12 minutes was recorded and used to estimate VO2 max.

Mental Health Assessment

Mental health status was evaluated using standardized questionnaires such as: Depression Anxiety Stress Scale

General Mental Health Questionnaire

These tools measure stress, anxiety, mood, and psychological well-being.

Air Pollution Measurement

Air pollution exposure was determined using the Air Quality Index (AQI) data obtained from official monitoring stations. $PM_{2.5}$ and PM_{10} levels were recorded for the study duration.

Procedure for administering tests:

A typical 400-meter track was used for the Cooper test. Within 12 minutes, the athletes ran or walked as far as they could. The test was preceded by a proper warm-up. The distance travelled was measured in meters. Mental health surveys were distributed in a controlled setting to ensure anonymity and correct comprehension of the questions.

To provide a precise exposure assessment, air pollution measurements were recorded concurrently on the testing days.

To ensure accuracy and reliability, the data for the current study, "Air Pollution Effect on Cardio Fitness and Mental Health of Sport Athletes, " were methodically gathered over a period of six to eight weeks. Permission was acquired from relevant institutions, coaches, and sports authorities prior to data collection. The goal of the study was explained to each participant, and their informed consent was acquired. Both primary and secondary data sources were used in the data collection procedure. Standardized psychological questionnaires and physical fitness tests were used to gather primary data directly from the chosen athletes. The Cooper 12-minute run/walk test was used to measure cardiorespiratory fitness, and each participant's distance travelled was measured in meters.

To ensure accuracy and dependability, the data for the current study on "Air Pollution Effect on Cardio Fitness and Mental Health of Sport Athletes" were methodically gathered over a period of six to eight weeks. Permission was acquired from relevant institutions, coaches, and sports authorities prior to data collection. The goal of the study was explained to each participant, and their informed consent was acquired. Both primary and secondary data sources were used in the data collection procedure. Standardized psychological questionnaires and physical fitness tests were used to gather primary data directly from the chosen athletes. The Cooper 12-min run/walk test was used to measure cardiorespiratory fitness, and each participant's distance travelled was measured in meters.

Figure:4 Hill region execution of the test.

Figure:5 Plain region execution of the test

Analysis, Interpretation and Results

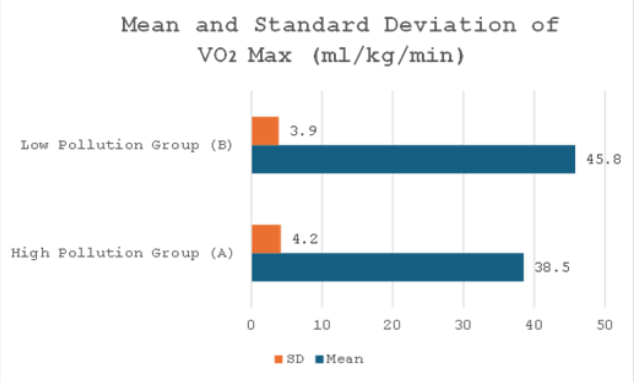
Statistical analysis was performed on the gathered data to ascertain the impact of air pollution on athletes' mental health and cardiorespiratory fitness. The findings are displayed with an explanation in both tabular and graphical form.

Analysis of Cardiorespiratory Fitness

Mean and Standard Deviation of VO_2 Max (ml/kg/min)

Table:1 Analysis of Cardiorespiratory Fitness

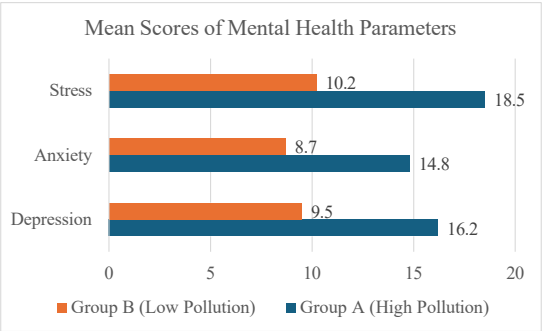
Group	Mean
High Pollution Group (A)	38.5
Low Pollution Group (B)	45.8



Graph:1 VO_2 Max Comparison Analysis of Mental Health (DASS-21 scores)

Table: 2 Mean Scores of Mental Health Parameters

Parameter	Group A (High Pollution)	Group B (Low Pollution)
Depression	16.2	9.5
Anxiety	14.8	8.7
Stress	18.5	10.2



Graph:2 Mental Health Comparison.

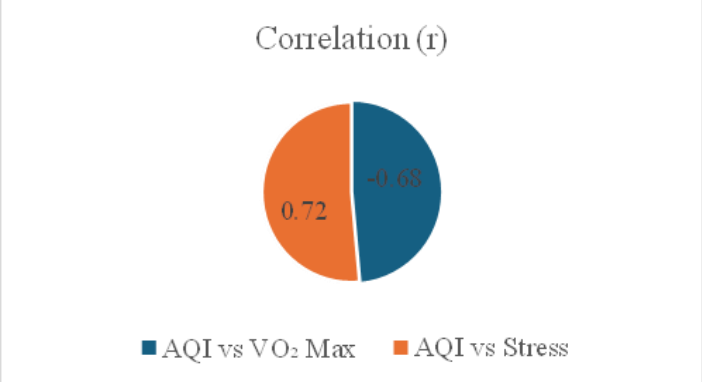
Interpretation:

Athletes exposed to higher air pollution levels exhibited significantly higher levels of depression, anxiety, and stress than those in low-pollution environments.

Correlation between Air Pollution and Fitness

Table: 3 Correlation (R-value)

Variables	Correlation (r)
AQI vs VO_2 Max	-0.68
AQI vs Stress	+0.72



Graph:3 Correlation Trend

Discussion And Conclusion

Discussion

The current study investigated how air pollution affects athletes' mental and cardiorespiratory health. The study's conclusions unequivocally show that environmental elements, especially air pollution, have a significant influence on athletes' physical and

mental performance. Athletes exposed to high levels of air pollution showed considerably lower VO_2 max values than those in low pollution conditions, according to the analysis of cardiorespiratory fitness. Inhaling pollutants, such as particulate matter (PM2.5) and nitrogen oxides, which damage lung function, restrict oxygen intake, and cause systemic inflammation, may be the cause of this decrease in aerobic capacity.

These results are in line with earlier studies that show that endurance performance and cardiovascular efficiency are adversely affected by polluted settings.

According to the study, athletes who lived in high-pollution areas had higher levels of stress, anxiety, and sadness. It is well recognized that exposure to contaminated air can cause oxidative stress and neuro-inflammatory reactions, which can impair emotional control and brain function. The physiological strain and decreased recuperation ability brought on by pollution exposure may be connected to the heightened stress levels seen in athletes.

Conclusion

The present study's results led to the following conclusions: Cardiorespiratory fitness in athletes is significantly impacted by air pollution. Athletes exposed to high pollution levels have lower VO2 max or aerobic capacity. Athletes exposed to air pollution had higher levels of stress, anxiety, and depression. Air pollution and physical fitness are negatively correlated, while pollution and mental health problems are positively correlated. The total performance and health benefits of physical activity are diminished while training in contaminated surroundings. Therefore, it can be said that air pollution is a significant environmental issue that negatively impacts athletes' mental and physical health.

Recommendations

During periods of high pollution, athletes should refrain from training. Indoor training facilities and the use of protective gear, such as masks, should be promoted. Before planning outdoor events, sports officials should monitor the Air Quality Index (AQI). Athletes exposed to contaminated settings should undergo regular health examinations. There should be awareness campaigns on how air pollution affects athletes' health.

Conflict of Interest: There is no conflict of interest between authors

Funding: This work did not receive any financial support from any organization.

Financial Interests: The authors declare that they have no financial interests.

Human and Animal Rights: NA

Ethics approval and consent to participate: Not applicable

References

Adams, W. C. (2006). Comparison of chamber 6.6-hour exposures to 0.04–0.08 ppm ozone via square-wave and triangular profiles on pulmonary responses. Inhalation Toxicology, 18(2), 127–136.

Balakrishnan, K., Dey, S., Gupta, T., Dhaliwal, R. S., Brauer, M., Cohen, A. J. & Daddona, L. (2019). The impact of air pollution on deaths, disease burden, and life expectancy across the states of India. The Lancet Planetary Health, 3(1), e26–e39.

Behn dig, A. F., Midway, I. S., Brown, J. L., Stenfors, N., Helle day, R., Duggan, S. T., & Blomberg,

A. (2006). Airway antioxidant and inflammatory responses to diesel exhaust exposure in healthy human volunteers European Respiratory Journal, 27(2), 359–365.

Block, M. L., & Calderón-Garcidueñas, L. (2009). Air pollution: Mechanisms of neuroinflammation and CNS disease. Trends in Neurosciences, 32(9), 506–516.

Brook, R. D., Rajagopalan, S., Pope, C. A., III, Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., & Kaufman, J. D. (2010). Particulate matter air pollution and cardiovascular disease. Circulation, 121(21), 2331–2378.

Brune reef, B., & Holgate, S. T. (2002). Air pollution and health. The Lancet, 360(9341), 1233–1242. Calderón-Garcidueñas, L., Solt, A. C., Henríquez-Roldán, C., Torres-Jardon, R., Nuse, B., Herritt, L., & Reed, W. (2008). Long-term air pollution exposure is associated with neuroinflammation. Brain

and Cognition, 68(2), 117–127.

Carlisle, A. J., & Sharp, N. C. C. (2001). Exercise and outdoor ambient air pollution. British Journal of Sports Medicine, 35(4), 214–222.

Chen, J. C., & Schwartz, J. (2009). Neurobehavioral effects of ambient air pollution. Neurotoxicology, 30(2), 231–239.

Chuang, K. J., Chan, C. C., Su, T. C., Lee, C. T., & Tang, C. S. (2005). The effect of urban air pollution on inflammation and coagulation. Occupational and Environmental Medicine, 62(12), 860–864.

Dey, S., Girolamo, L. D., Donelan, A. V., Tripathi, S. N., Gupta, T., & Mohan, M. (2012). Variability of outdoor fine particulate matter in Indian cities. Atmospheric Environment, 49, 154–163.

Dockery, D. W., Pope, C. A., Xu, X., Spengler, J. D., Ware, J. H., Fay, M. E., ... & Speizer, F. E. (1993). An association between air pollution and mortality. New England Journal of Medicine, 329(24), 1753–1759.

Gauderman, W. J., Aval, E., Gilliland, F., Vora, H., Thomas, D., Berhane, K., ... & Peters, J. (2004). The effect of air pollution on lung development. New England Journal of Medicine, 351(11), 1057–1067.

Giles, L. V., & Koehle, M. S. (2014). The health effects of exercising in air pollution. Sports Medicine, 44(2), 223–249.

Gold, D. R., Litonjua, A., Schwartz, J., Lovett, E., Larson, A., Nearing, B., & Verrier, R. L. (2000).

Ambient pollution and heart rate variability. Circulation, 101(11), 1267–1273.

Guttikunda, S. K., & Gurjar, B. R. (2012). Role of meteorology in seasonal pollution cycles.

Environmental Monitoring and Assessment, 184(5), 3195–3212.

Health Effects Institute (HEI). (2020). State of global air 2020 report. HEI Publications.

Kelly, F. J. (2003). Oxidative stress: Its role in air pollution and adverse health effects. Occupational and Environmental Medicine, 60(8), 612–616.

Kargar Fard, M., Poursafa, P., Rezanejad, S., & Mousselines, F. (2011). Effects of exercise in polluted air on lung function. Iranian Journal of

Environmental Health Science & Engineering, 8(3), 259–266.

Landrigan, P. J., Fuller, R., Acosta, N. J. R., Adeyi, O., Arnold, R., Basu, N., ... & Zhong, M. (2018).

The Lancet Commission on pollution and health. The Lancet, 391(10119), 462–512.

Lim, Y. H., Kim, H., & Kim, J. H. (2012). Air pollution and symptoms of depression in elderly adults.

Environmental Health Perspectives, 120(7), 1023–1028.

McDonnell, W. F., Stewart, P. W., Smith, M. V., Pan, W. K., & Pan, W. H. (1999). Ozone exposure and respiratory function. American Journal of Respiratory and Critical Care Medicine, 160(3), 828–83